Development and Forecast of China's Nature Gas Industry

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Introduction

With the rapid development of national economy in China, the demand for energy resources is also growing. Because the country has been paying more and more attention to the environmental protection, China's energy industry, as other countries in the world, is subject to the inexorable trend of developing and utilizing high quality energy, increasing economic efficiency, and improving people's living condition.

Gas, as a kind of ecologically clean and high quality energy, has not been fully developed and utilized yet in China. Gas takes up only 2 percent in primary energy consumption structure, lagging far behind the world's average level of 24 percent. In order to ensure sustainable development of the national economy, China's gas industry must take a great leap forward.

This issue has been given great emphasis by the government, and has become an important factor for the country in making energy-related strategies. CNPC has regarded gas development as a new point for economic growth, and is taking all possible measures to stimulate gas industry development.

1. Present situation of gas development and utilization

China is among the first countries that exploited and utilized gas. In the past decades, with the development of petroleum industry, gas industry has also been developed. Especially since the 80's, the country has enhanced its effort in gas exploration and development, and developed the so-called "four gas bases" in central and west China, namely, Sichuan, Changqing, Qinghai and Xinjiang gas bases as well as offshore gas fields, all these have greatly changed the structure of China's gas industry.

1.1 Gas resources

China is in possession of rich gas resources. According to the second round of "China petroleum and gas resource assessment" in 1994, China's 69 gas–bearing sedimentary basins contain 38 $x10^{12}m^3$ of gas reserve, including $29.9x10^{12}m^3$ onshore reserve and 8.14 $x10^{12}m^3$ offshore reserve. The distribution of onshore gas reserve are shown in Table 1-1.

Table 1-1 Distribution of onshore gas reserve

Regions	Xinjiang	Qinghai	Shaangan-ning	Chuanyu	East China	Others	Total
Reserve ($10^{12}m^3$)	9.98	1.05	4.15	7.36	2.99	4.34	29.9

China's gas resources relatively concentrates in the central-west four gas bases, including Xinjiang gas base (Tarim, Junger, and Tuha basins), Qinghai base (Qaidam basin), Shaanganning gas base (Erdos basin), Chuanyu gas base (Sichuan basin), east China (Songliao and Bohai bay basin), and offshore areas (the East Sea and the South China Sea).

1.2 Exploration and development

After years of extensive and thorough work, gas exploration has made considerable achievements. The proved gas reserve is as much as 2.9 $x10^{12}m^3$, of which 2.24 $x10^{12}m^3$ are onshore proved reserve.

Gas production bases have been set up nationwide, such as Chuanyu, Shaanganning, Qinghai, Xinjiang, east China and offshore production bases. Production of 1997 has reached 22.3 $x10^9m^3$, of which CNPC claimed 17.2 $x10^9m^3$, or 77% of total, and CNSPC and CNOOC takes up 5.1 $x10^9m^3$ together.

The proven onshore gas reserve and production are shown in Tables 1-1 and 1-3

Table 1-2 Onshore Gas Exploration Outcome (1997) 10^9m^3

Regions	Proved reserve
East China	854.413
Shaaanganning	323.487
Chuanyu	537.877
Qinghai	67.013
Xinjiang	427.711
Others	32.521
Total	2243.022

Table 1-3 Onshore Gas Production in 1997 10^9m^3

Regions	Production	Proportion against the overall production of CNPC and SinoPec %
East China	7.06	41.1
Shaanganning	0.17	1.0
Chuanyu	7.51	43.7
Qinghai	0.22	1.3
Xinjiang	2.02	11.8
Others	0.20	1.1
Total	17.18	100

1.3 Gas utilization

Due to the low gas production in China, its utilization is largely dependent on the production.

The main gas consumers are neighboring cities, towns, and industrial zones of the gas fields, and gas in these areas is used mainly for producing chemical fertilizers, power generation, domestic fuel, gas field development as well as other industrial purposes. In 1998, China's gas utilization has run as high as 22.1x 10^9m^3 . Proportion of gas consumption among different applications is shown in Table 1-4.

Table 1-4 Gas Consumption Breakdown

Item	Chemi-cal fertiliz er	Civil use	Pow er gene ra-tion	Chemi cal industr y	Com-merce	Field use	Other industri es	Other s	Tot al
Consu m-ption 10^9m^3	6.9	2.2	3.5	0.8	0.1	6.1	1.1	1.4	22. 1
Propor -tion, %	31.22	9.95	15.8 4	3.62	0.4	27.61	4.98	6.33	100

As it is revealed, natural gas is still found at a low level of utilization, and takes up only 2 percent or so in the primary energy consumption framework (See Table 1-5).

Table 1-5 Energy consumption structure %

Year	Solid fuel	Liquid fuel	Natural gas	Hydro- and nuclear power
1990	76.2	16.6	2.1	5.1
1995	74.6	17.5	1.8	6.1
1997	73.5	18.6	2.0	5.9

1.4 Pipeline construction

With the gradual gas exploitation and utilization, gas pipelines, as a link connecting the gas field with the consumers, have also been developed. The country's existing gas pipelines ($\geqslant$ 426 mm in diameter) have accumulated to 5700 km, with the trunk line throughput rate of 11x10^9m^3/a. The recently constructed Shaan-Jing gas pipeline (extending 860 km in length, initial throughput rate: 2x10^9m^3/a) and the South Sea (Ya-13-1)-Hong Kong gas pipeline (860 km in length, initial throughput rate: 2.9 x10^9m^3/a) are examples of the advanced gas transportation pipelines.

Shaan-Jing gas pipeline, together with other connected pipelines, forms the gas pipeline system in Shaanganning and north China, carrying the natural gas produced in these areas to Beijing, Tianjin, Xi'an and other neighboring areas.

In Sichuan and Chongqing areas, a relatively complete transportation and distribution

system has been formed, with a ring-shaped trunk line of 1451 km consisting of south and north semi-loops. In general, gas pipelines of other regions directly link the consumers with the gas fields.

2. Prediction of gas exploration and development

At the present, gas resource in China is rather under-explored, with exploration level of about 7.6 percent, which means a great exploration potential and a good resource basis for further development of gas industry.

2.1 Exploration activities and reserve increase

Gas resources are mainly distributed over the onshore west and central regions and offshore areas, while market potentials lie in economically better-developed east China. On this occasion, principles for exploration are set as:

- enlarging the central region exploration, deepening the east region exploration, and speeding up the west region exploration;
- centering around economic efficiency;
- focusing on exploration of the central and coastal areas near the markets in order to stimulate gas utilization.

As to reserve increase, it is predicated that by 2010 the annual increase is approximately 150-200 $x10^9m^3/a$, thereby the accumulated increase will be 1.9-2.3 $x10^{12}m^3$ and by 2010, the accumulated proved reserve will be 4.1-4.5 $x10^{12}m^3$. Among which, CNPC's newly added proved reserve accounts for 1.5-1.7 $x10^{12}m^3$, with $3.1x10^{12}m^3$ coming from "four gas bases", while CNOOC and CNSPC together take up 400-600 $x10^9m^3$. Prediction of the proven reserve increase is shown in Table 2-1.

At the present, the central west 'four big gas bases' and offshore explorations have all turned up with important discoveries and remarkable achievements. So to hit this reserve target is in sure hand.

Table 2-1 Predicted Newly Added Reserve

10^9m^3

Time period	Shaan-gannin g	Chuan-yu	Qingha i	Xin-jiang	The east region	CNPC total	CNOO C and others	Total
1998-2010	360	400	295	451-651		1506-1706	400-600	1900-2300
Accum u-lated proved reserve in 2010	683.5	937.8	362	878.7-1078.7	1000	3862-4062	1000-1300	4100-4500

It is predicted that after 2000, gas reserve will be further increasing by 150 $x10^9m^3$ every year. By 2020, the newly added proven reserve will hit around $1.5x10^{12}m^3$, and the total accumulated proven reserve will be 5.5-6 $x10^{12}$ m^3.

2.2 Gas production

By 2010, China's gas production is expected to reach 70 x10^9m^3, with of 50 x10^9m^3 from CNPC, and 20 x10^9m^3 from CNOOC and others. By 2020, China's gas production is predicted to reach about 100 x10^9m^3. Gas production of the main gas-bearing areas is shown in Table 2-2.

Table 2-2 Predicted Gas Production **10^9m^3**

Regions	Gas production		
	2000	2010	2020
The east region	7	7	
Chuanyu	10	13	
Changqing	3	10	
Qinghai	1.5	5	
Xinjiang	3.5	15	
CNPC total	25	50	70
CNOOC and others	5	20	30
Total	30	70	100

It is predicted that after 2020 gas production will continue its growth until it reaches the production peak at 110-130x10^9m^3/a in 2025.

3. Prediction of gas consumption

Synchronic and harmonious development of gas field and utilization project is the key factor to speed up progress of gas industry. And it is of special importance to China, whose gas industry is still found at the beginning stage, to develop and cultivate the gas market.

3.1 Gas demand

China has a big potential of gas utilization. Based on the energy demand arising from the development of national economy and the changes in energy structure, we have made a prediction of China's gas demand by method energy elastic coefficient, which has revealed a preliminary demand of 30-100x10^9m^3 during 2000-2010 period (Table 3-1). The total gas demand of different areas has brought forth a figure even higher than the prediction (Table 3-2).

Table 3-2 China's gas demand prediction (by elastic coefficient method)

Year	GDP %	Elastic coefficient	Proportion of gas in energy	Predicted gas demand 10^9m^3/a
1997	8.8		2.0	22.3
2000	7.18	0.5	2.3	30.0
2010	6	0.4	6	101.0
2020	6	0.3	8	160.6

Table 3-2 Gas demand of different regions **10^9m^3**

Regions	2000	2010
Northeast region (Liaoning, Jilin, Heilongjiang)	5.7	18.9
Circum-Bohai (Beijing, Tianjin, Hebei, Shandong)	5.3	26.6
Yangtze River delta region (Shanghai, Jiangsu, Zhejiang)	1.4	31.0
central south region (Hubei, Hunan, Anhui, Henan)	1.4	17.3
central region (Inner Mongolia, Shaanxi, Shanxi, Ningxia,Sichuan)	8.0	16.1
west region (Xinjiang, Gansu, Qinghai)	2.1	5.2
total of the planned regions	23.9	115.1
south region (Guangdong, Fujian)	5.5	21.4
Total	29.4	136.5

3.2 Gas market characteristics

Investigations have shown that, gas markets are geographically located in the east and south regions of China. However, gas demand from the northeast China, circum-Bohai area, the Yangtze River delta region and the south China during 2000-2010 period takes up 60-70 percent of the total demand of the investigated areas (25 provinces, cities and regions). The Yangtze River delta region, with its more rapid economic growth, will have an even bigger potential demand (40 percent of the east region's demand in 2010).

Among the four applications, power generation, chemical materials, industrial fuel, domestic and commercial use, gas will be largely used as industrial fuel and chemical materials in the near future (by 2000), and for power generation and domestic purposes during 2005-2010 (See Tables 3-3 and 3-4).

Table 3-3 Gas demand Breakdown 10^9m^3

Applications	2000	2005	2010
Power generation	2.0	17.4	48.4
Chemical industry	7.8	12.0	18.0
Industrial fuel	10.7	16.8	25.7
City fuel	3.3	10.6	23.0
Total	23.9	56.9	115.1

Table 3-4 Gas Demand Structure %

Applications	2000	2005	2010
Power generation	8	31	42
Chemical industry	33	21	16
Industrial fuel	45	30	22
City fuel	14	19	20

3.3 Changes in energy consumption structure

With the quickening up of gas utilization, China's gas consumption structure will undergo some changes, gas's share will be increased from 2% to 8% in 2020, while proportion of coal will be reduced (Table 3-5). Thus a better ecological and social effect will come about.

Table 3-5 Changes in the Primary Energy Consumption Structure %

Year	General energy consumption 10^9tce	Solid fuel	Liquid fuel	Natural gas	Hydro- and nuclear power
1997	1.44	73.5	18.6	2.0	5.9
2000	1.63	73.4	17.9	2.3	6.4
2010	2.04	68.4	16.8	6.0	8.8
1020	2.44	65.8	16.4	8.0	9.6

It is predicted that by 2000 domestic gas will meet the gas market demand on the whole; but in 2010 domestic gas will go short of the market demand, and pipeline gas and LNG shall be imported to fill up the deficiency. By that time domestic gas supply will take up 60% of the market demand.

4. West-east gas pipeline project

4.1 Principles for gas supply

Predication shows that gas reserve increase will mainly focus on the central and west "four gas bases". It is estimated that by 2010, beside the supply for local provinces, cities and autonomous regions, some $24.6x10^9m^3/a$ gas will be transported through pipeline system to the east region with a bigger market demand. So the basic principle for gas supply is "to transport west gas eastwards".

In order to shorten the supply distance and improve gas supply efficiency, proposed supplying areas will be narrowed down to the Yangtze River delta region and the areas north to it, while south China will be supplied with imported LNG and natural gas from offshore gas fields.

Gas produced in the east region (some $7x10^9m^3/a$ in 2010), mainly in the form of associated gas, will continue to feed the demand of the existing consumers.

Natural gas or coal-bed gas from CNSPC and China United Coal-bed Methane Corporation will go to the neighboring consumers of the gas fields.

Natural gas produced from offshore fields of CNOOC will supply the nearby coastal consumers.

4.2 West-east gas pipeline project

The keynote of the west-east gas supply scenario is "resource replacement and step by

step construction ".

Firstly, gas resources from Chuanyu and Shaanganning regions are planned to go to the Yangtze River delta region and Hubei province in an effort to stimulate the east China market. Therefore Chuanyu-Wuhan-Xinyang, Shaanganning-Xinyang-Shanghai pipelines are to be built at the first stage;

Secondly, take Qinghai basin as gas replacement area, build Qinghai-Lanzhou, Lanzhou-Xi'an pipelines to continuously supply gas to Yangtze River delta areas.

Finally, gas from Tarim region of Xinjiang joins in to add to the supply for the Yangtze River delta region and other areas. Therefore a pipeline from Tarim to Lanzhou is to be constructed.

It is predicted that by 2010, $19x10^9m^3$ gas from the four gas bases will go to Yangtze River delta region, Hubei and Henan provinces. Gas supply at different stages is shown in Table 4-1.

Table 4-1 Gas Supply at Different Stages **10^9m^3**

Construction period	Total supply	Chuanyu	Shaanganning	Qinghai	Xinjiang
First stage	5	3	2		
Second stage	9	3	3	3	
Third stage	19	3	3	3	10

Table 4-2 shows the principle technical parameters of pipeline construction scenario at different stages

Table 4-2 Principle Technological Parameters of Pipelines

Construction period	Starting and terminal points	Pipeline length (km)	Pipeline diameter (mm)
First stage	Zhongxian-Wuhan	703	711
	Wuhan-Xinyang	180	610
	Jingbian-Xi'an	460	660
	Xi'an-shanghai	1444	914
	Sebei-Lanzhou	997	711
Second stage	Lanzhou-Xi'an	510	914
Third stage	Lunnan-Lanzhou	2258	914

At the same time, it should be taken into consideration to import natural gas from neighboring countries, build appropriate long-distance transnational gas pipelines, and to connect them to the west-east gas pipeline system to increase supply volume and improve supply stability.

Conclusion

Accelerating the development of gas industry is an important measure for improving China's energy consumption structure and guaranteeing sustainable development of the national economy. East China possesses large gas demand and great market potential. It is predicted that the beginning of the next century will see a big leap forward in China's natural gas industry.

China's rich gas resources and rapidly growing reserve have laid a solid resource foundation for gas development while "west-east gas pipeline project " is the prerequisite to achieve this goal. Import of gas and LNG are supplement to domestic gas supply.

While accelerating gas exploration and development, measures should be taken to cultivate gas market to as to achieve well coordination among field development, pipeline construction and gas project to promote utilization of natural gas in China.